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BIOLOGY AND ECOLOGY OF ENCRUSTING BRYOZOANS IN MONTEREY HARBOR

by

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ABSTRACT:

The encrusting bryozoans Celleporaria brunnea, Cryptosula pallasiana and Tubulipora tuba are the dominant bryozoans and often the dominant fouling organisms in Monterey harbor. By using panels as collecting surfaces, the general biology and ecology of these three species have been investigated. All three settle and grow at depths from the surface down to 25 feet but the optimum depth for settlement and growth is just below the low tide mark. Release of larvae and settlement occurs erratically throughout the year with no species showing a "season" for settlement. Growth rates have been measured throughout the year for each species. The spreading colonies of Celleporaria brunnea and Cryptosula pallasiana have a definite inhibiting influence on the settlement of barnacle and serpulid larvae, and often cover and smother previously settled barnacles, serpulids, and borers such as Limnoria. Celleporaria colonies were preyed upon by Thysanozoon californicum, a flatworm that closely mimics the color and texture of the bryozoan.

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Biology and Ecology of Encrusting Bryozoans in Monterey Harbor

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Introduction

During the past five years intensive studies on the boring and fouling organisms in Monterey Harbor have been made and have been reported on (Mommsen, 1966; Miller, 1966; Haderlie, 1968a, 1968b, 1969, 1970; Smith and Haderlie, 1969). In all of these studies in the harbor the dominant fouling organisms have been found to be encrusting cheilostomate and cyclostomate bryozoans. Although identification of bryozoans is difficult and young developmental stages often have different morphology from adult colonies, it has been possible to separate the various forms and it appears that approximately fourteen species occur in the harbor. Of these, the encrusting cheilostomes *Celleporaria brunnea* (Hincks, 1884) and *Cryptosula pallasiana* (Moll, 1803) and the cyclostome *Tubulipora tuba* (Gabb and Horn, 1862) are dominant throughout the year and at all depths from the surface down to 25 feet depth.

During the year 1969-1970 an intensive study of these three species of bryozoans was initiated and is the subject of this report. The original objectives of the research were to study the basic biology and ecology of these three species of bryozoans and specifically (a) to determine the period of reproduction and settlement of larvae, (b) to determine depth preference, (c) to investigate the mechanism of larval attachment and metamorphosis,

(d) to measure rate of growth of bryozoan colonies, (e) if possible to determine food habits, (f) to investigate the influence of the bryozoans on the settlement of other fouling organisms and (g) to study a common flatworm predator feeding on one of the bryozoan species.

It was realized at the beginning that this was a very difficult group to work with. Very few studies on bryozoan biology have been made. The major obstacle encountered during this year of study was the inability to keep the colonies of animals or the larvae alive in the laboratory despite the fact that our laboratory is on the beach with fresh sea water circulating through the aquaria. Essentially all studies, therefore, had to be carried out on test panels submerged at various depths in the harbor area. This made it virtually impossible to meet a number of the objectives mentioned above. None-the-less, a considerable amount of data was collected and many of the objectives were met.

Area of Study and Methods

The area of study was a site in Monterey Harbor near the outer end of Municipal Wharf No. 2 about 1000 meters from shore in water 25 feet deep. This is the site where fouling studies have been in progress for some years. Previous studies indicated that 8 inch by 10 inch plywood panels were suitable collecting surfaces for all bryozoans, so racks of these panels were suspended at various depths and positions. The optimum depth for collecting the three species under investigation was about 1 foot below the lowest tide, therefore, much of the data collected were from these panels.

Panels were exposed to the water for various periods of time to determine periods of settlement and growth rates. One set of panels designated Short Term panels were exposed for one month only, being placed in the water at the beginning of one month and removed at the beginning of the next. A second set was designated Long Term panels and these were submerged at the beginning of one month and removed three months later. A third set called Cumulative panels were submerged at the beginning of the study, removed for examination periodically, then replaced in the water for periods up to one year.

After removal from the racks in the harbor the panels containing the living bryozoans were transported to the laboratory in tubs of cold sea water and were kept in sea water while being examined microscopically.

Plankton samples were regularly collected from the water adjacent to the racks and pilings of the harbor to collect larval stages. The cyphonautes larvae of bryozoans were segregated from the remaining plankton and an attempt was made to rear these in aquaria.

Discussion of Results

The results obtained from this study will be discussed in relation to the basic objectives as listed above in the introduction. In some cases data collected during the 1969-1970 year study have been supplemented by data obtained earlier in basic fouling studies in the area.

1. Period of Reproduction and Settlement of Larvae

Short Term panels that were submerged for one month periods throughout the year collected newly settled bryozoans and made possible a

determination of reproduction periods and time of settlement. Figs. 1, 2, and 3 illustrate the periods of settlement of the three species of bryozoans, and the numbers of larvae settling during any one month on a wooden panel surface 8" x 10" in size. Data from the 1969-1970 year of study are plotted on the right in each figure and data, where available, from earlier fouling studies are shown on the left. It is clear from all these figures that settling times and intensity varies from year to year. Each species will be discussed separately.

Celleporaria brunnea settled on panels in Monterey Harbor throughout the year during certain years (such at 1969-1970) but at other times (1966-1968) none or very few settled in November, December and January. The erratic nature of the settlement is illustrated by the fact that none settled in November 1967, but a total of 60 settled on a single panel surface during November 1969.

Cryptosula pallasiana settled in far fewer numbers than the other two species, and for the first 8 months of 1970 none settled at all. As can be seen from Figure 2, however, over the years Cryptosula can be expected to settle during any month of the year and in no one season is this species markedly more abundant than in any other.

Tubulipora tuba also showed an erratic and unpredictable settlement and at one time or another was found to have settled during every month of the year. An example of the strange pattern of settlement is illustrated in Figure 3 where during February 1968 over 100 larvae settled where as in February 1970 none settled.

FIGURE 1

Settlement of _Celleporaria brunnea_

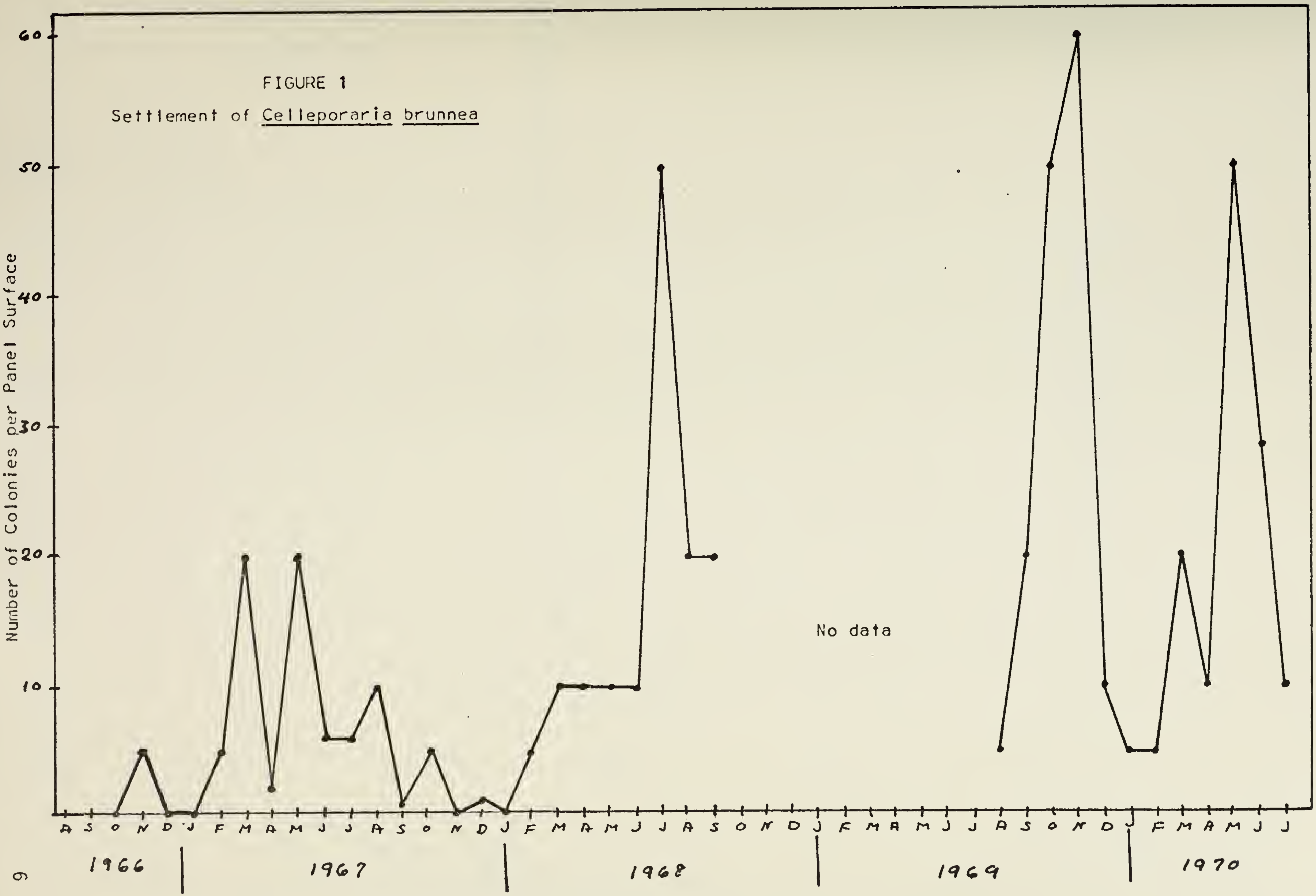
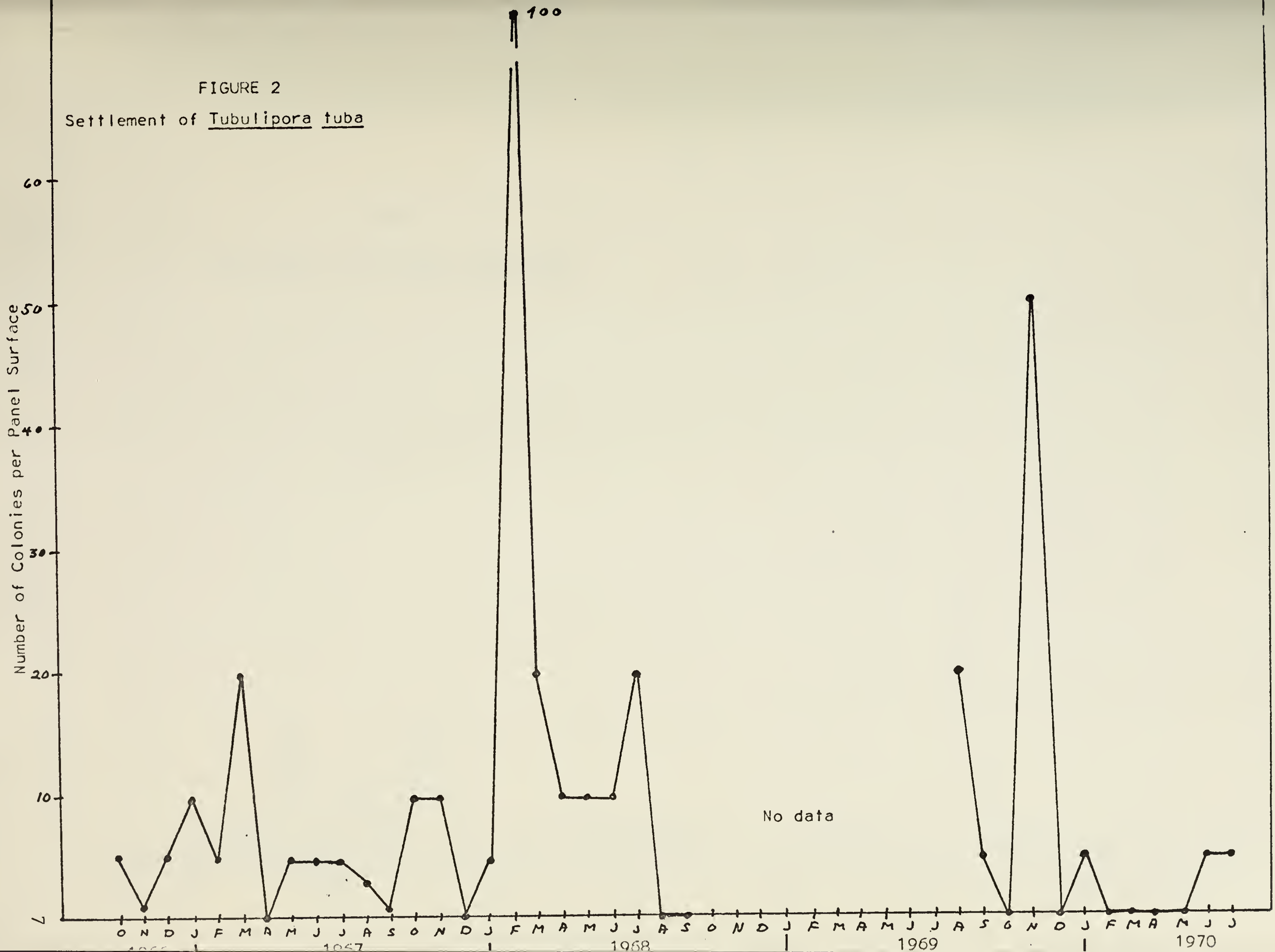


FIGURE 2

Settlement of *Tubulipora tuba*



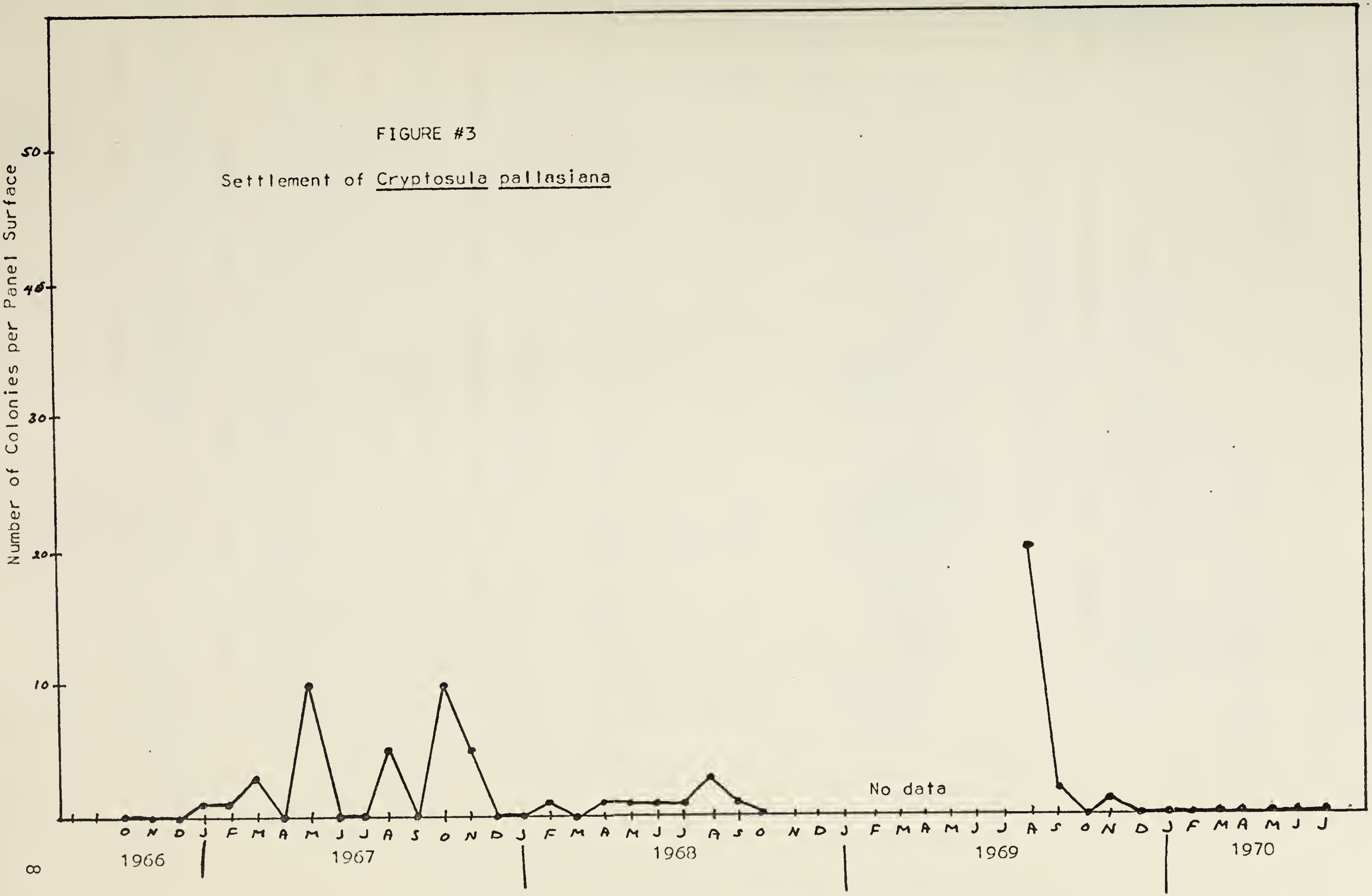


FIGURE #3
Settlement of Cryptosula pallasiana
Number of Colonies per Panel Surface
50
40
30
20
10
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
1966
1967
1968
1969
1970
No data

2. Depth Preference

During this study panels were suspended in various water depths and positions. Some were placed just below the low tide level, some near the bottom in 25 feet of water, others were placed in the intertidal area where they were exposed about one half the time and submerged the other half. Table I presents data from one typical year.

Table I

Bryozoan Settlement on Panels at Different Position

	Number of test panels on which bryozoans settled			
	Intertidal Panels	Floating Panels	Shallow Water Panels	Deep Water Panels
Celleporaria brunnea	7	4	19	14
Cryptosula pallasiana	8	8	12	5
Tubulipora tuba	2	2	22	20

All three species showed a preference for shallow water depths, yet were found at all depths investigated.

3. Larval Attachment and Metamorphosis

During 1969-1970 an attempt was made to study the method of attachment of settling larvae and the metamorphesis of the larvae. Plankton samples were collected in the vacinity of the panels on a regular basis. A standard #20 phytoplankton net was used to make vertical hauls. Cyphonautes larvae were found, usually in small numbers, in practically all of these hauls. Morphologically these larvae looked very much alike and could represent any one of the 14 or more species of bryozoans in the harbor. The cyphonautes were carefully segregated from the remaining plankton and

were kept in running sea water in the laboratory. It was hoped that the larvae would settle on small wooden panels, but in all cases the larvae died before settlement. On many occasions, newly removed panels from the harbor had recently settled bryozoans consisting of one or two zooids, yet in no case were cyphonautes larvae found in contact with the panels. Many marine bryozoans have been reported to have highly modified cyphonautes larvae, so it is possible that these have not been recognized in this study.

4. Growth Rates

Growth rates of each of the three species were investigated. On the Short Term panels that were in the water one month, the colonies could represent young newly settled forms to those up to one month in age. The size of these colonies therefore represented the maximum growth that occurred in one month. Likewise, the Long Term panels were in the water for three months and this was, therefore, the maximum age of the colonies. Cumulative panels were exposed for up to 12 month, so some of the bryozoans could be one year old on these panels. By measuring maximum colony size on each of these types of panels one can gain some knowledge of growth rates. Each species will be discussed in turn and the data given are from panels submerged in the shallow water position.

Celleporaria brunnea can be recognized by the orange lophophore of the polypide and by the very dark opercula and avicularia. Thus, beginning colonies consisting of single zooids could be recognized. Many Short Term panels had these small, newly settled forms. The maximum size any of the colonies achieved in the first month of growth was a colony diameter of 4.0 mm and this was observed on a panel submerged during November 1969.

This same panel also had the maximum number of colonies ever observed (60 per panel side). As a rule, throughout the year, the maximum size achieved in one month or less was between 1.0 and 2.0 mm colony diameter. Long Term panels exposed for 3 month periods throughout the year invariably carried many Celleporaria colonies and the largest of these were from 10 to 15 mm diameter although a few were 20 mm. On many 3 month panels, colonies of this size completely blanketed the panel surface. The maximum diameter of Celleporaria colonies on 6 month panels was 25 mm and at the end of 12 months the colonies were overlapping one another and so crowded that size determination was difficult, but many discrete colonies were 30 mm across. Had crowding not occurred they probably would have been much larger.

Cryptosula pallasiana settled in fewer numbers than the other two bryozoans, but the colonies had a more rapid growth rate and achieved a larger size. Many colonies were 8 - 10 mm in diameter after one month or less of growth. Occasionally established colonies on the racks holding the panels would spread on to the panels, and in some cases this asexual reproduction of the zooids would result in a colony 30 mm across in one month or less of growth. After 3 months Cryptosula colonies were often 40 mm or more across and had grown over other organisms. Where the edges of colonies met they would turn up resembling water lily pads. Colonies six and twelve months old were massive spreading layers with amorphous shapes. Crowding often caused the edge of the colony to grow out at 90° from the panel and on the edges sticking outward from the panel two layers of zooids, back to back, would develop.

The cyclostome Tubulipora tuba had a growth rate up to 2.5 mm colony diameter after one month or less of growth. Small colonies were fan-shaped with the calcareous tubes parallel to the panel surface. Older colonies became more circular in outline with the ends of the tubes projecting out from the panel face. After 3 months growth Tubulipora colonies averaged 10 mm in diameter, and after 12 months colonies were as much as 20 mm in diameter.

5. Food Habits

During this study it was hoped to learn something regarding the food habits of these encrusting bryozoans. The ciliated lophophores of Tubulipora tuba and Cryptosula pallasiana were relatively small and inconspicuous and were often withdrawn during periods of study. In Celleporaria brunnea, however, the lophophores were readily extended and were easy to observe. The color of the tentacles is very distinctive, being a reddish orange. Small planktonic diatoms placed in a pan of water could be seen to be swept down the ciliated tentacles to the mouth. Small pieces of detritus were treated the same way. As far as could be observed there was no selectivity in food capture provided the particles were the right size. Copepods and other larger organisms would often brush the tentacles but were never seen to be captured. To determine gut contents, a few polypides were dissected, but digestion in the stomach appeared to be very rapid and none of the material in the stomach could be identified.

6. Influence of Encrusting Bryozoans on the Settlement of Other Foulers and Borers

It was observed during this study that large colonies of

Celleporaria brunnea and *Cryptosula pallasiana* often had a very distinctive influence on other fouling organisms. Panels exposed for 3 months often carried practically 100% coverage with *Celleporaria*. These colonies, averaging 10-15 mm in dimater, were often in contact with one another over the entire surface. Foulers such as the serpulid worm *Spirorbis* sp. and the acorn barnacle *Balauus crenatus*, that had settled when the bryozoan colonies were smaller, were often completely covered and smothered by *Celleporaria* and *Cryposula*. At least during the first twelve months of growth nothing settled on the surface of the bryozoan colonies although in spaces between colonies other attached foulers occurred. On some panels the isopod borer *Limnoria quadripunctata* often attacked the wood early during submergence. After 3 months, however, encrusting *Celleporaria* and *Cryptusula* have covered over the *Limnoria* burrows and the borers were smothered.

In separate studies in the harbor involving populations on pilings it has been noted that over a long period of time (24 months or more) an ecological sequence occurs where encrusting bryozoans practically invariably preceed the establishment of the climax *Mytilus edulis* community. On panels during this study it was observed that only after a bryozoan population was established (3 months or more) would tunicates settle on the panels.

7. Predators

An interesting predator-prey relationship was observed early in this study and has been followed since. It involves the papillated flatworm *Thysanozoon californicum* and the bryozoan *Celleporaria brunnea*.

Thysanozoon is a small flatworm that is oval in outline and about 15 mm maximum length. It is very distinctive in that the dorsal surface is covered with a felt-like series of projecting papillae. In Monterey Harbor this flatworm has been observed only in contact with colonies of Celleporaria brunnea, and the similarity of these two species in texture and color is most remarkable and represents a striking example of protective coloration. Until one becomes alert to the presence of the flatworm it is easy to miss seeing it, even when observing under a dissecting microscope. The zooecia of Celleporaria are yellowish orange in color, the lophophore is reddish orange, and the opercula and avicularia are dark brown to black. Thysanozoon has much the same color with a yellowish ground color, redish orange papillae resembling the bryozoan lophophore in color and texture, and dark brown spots resembling the opercula and avicularia. The flatworm is very sluggish and does not move unless prodded. When settled on a Celleporaria colony it practically perfectly matches the background. Since first detecting this flatworm 4 years ago it has been seen regularly on panels and piling, but never except in contact with Celleporaria. When the flatworm is lifted up from the bryozoan, it often has its pharynx extruded as a large ruffled mass over the bryozoan colony, and often all the polypides under the flatworm are gone with only the whitish zooecial walls remaining. The flatworm is obviously a predator on the bryozoan, but on any one panel containing up to 50 or more large colonies of Celleporaria only a few flatworms were ever found. A colored photograph of the bryozoan and flatworm will appear in a book to be published next year by Stanford University Press (Morris and Abbott, in press).

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13. ABSTRACT

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